

## WHAT IS CLAIMED IS:

1. A method of setting up image-on-paper of an image forming device, comprising:
- 5 generating a test pattern;  
printing the test pattern on a sheet;  
measuring at least one test pattern parameters;  
using the measured test pattern parameters to determine at least one registration error in at least one of image squareness, image skew, sheet skew, process magnification, lateral magnification, image to sheet position in the lateral direction and image to sheet position in the process direction; and
- 10 using the determined at least one error to adjust at least one operational parameter of the image forming device.
2. The method of claim 1, wherein:
- 15 printing the test pattern includes printing the test pattern on both a first side of the image recording medium and on a second side of the image recording medium;
- measuring the test pattern parameters comprises measuring the test pattern parameters on both the first side and the second side of the image recording medium; and
- 20 adjusting at least one operational parameter includes adjusting at least one of a pixel clock frequency, a photoreceptor speed and at least one image-on-paper actuator based on the determined errors.
3. The method of claim 1, wherein the test pattern comprises a plurality of crosshair targets.
- 25 4. The method of claim 1, wherein a sheet position is registered at an outboard edge and at a leading edge of the sheet for an obverse side of the sheet.
5. The method of claim 1, wherein the at least one measured test pattern parameter includes at least one of a distance from a center of a leading edge crosshair located near an inboard leading edge of the image recording medium to a center of a trailing edge crosshair located near an outboard edge of the image recording medium, a distance from the center of a leading edge crosshair located near an outboard leading edge of the sheet to the outboard edge of the sheet, a distance between the center of a leading edge inboard crosshair to the center of a leading edge outboard crosshair, a
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distance between the center of a leading edge outboard crosshair to the center of a trailing edge outboard crosshair, and a measured distance between a leading edge of the sheet to the center of a leading edge outboard crosshair, and a distance between a trailing edge of the sheet to the center of a trailing edge outboard crosshair.

- 5           6.       The method of claim 1, wherein determining at least one registration error in paper skew comprises measuring the test pattern parameters of  $d_1$ ,  $e_1$ ,  $f_1$ ,  $d_2$ ,  $e_2$  and  $f_2$  and performing at least one geometrical transformation, including

$$\theta = (\tan^{-1}[(f_1 - e_1) / d_1] + \tan^{-1}[(f_2 - e_2) / d_2]) / 2$$

10       where  $\theta$  is the amount of rotation of the sheet about the outboard registration edge of the sheet,  $d_1$  is the distance between the two leading edge (LE) crosshair centers on the first side of the sheet,  $e_1$  is the distance from the outboard (OB) edge of the sheet to the center of the leading edge (LE) outboard (OB) crosshair on the first side of the sheet,  $f_1$  is the distance from the outboard (OB) edge of the sheet to the center of the trailing edge (TE) outboard (OB) crosshair on the first side of the sheet,  $d_2$  is the  
15       distance between the two leading edge (LE) crosshair centers on the second side of the sheet,  $e_2$  is the distance from the outboard (OB) edge of the sheet to the center of the leading edge (LE) outboard (OB) crosshair on the second side of the sheet, and  $f_2$  is the distance from the outboard (OB) edge of the sheet to the center of the trailing edge (TE) outboard (OB) crosshair on the second side of the sheet.

- 20           7.       The method of claim 1, wherein determining at least one registration error in raster output scanner skew comprises at least one geometrical transformation, including

$$\phi = (\phi_1 + \phi_2) / 2$$

where:

25            $\phi$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface;

$\phi_1$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface for first side of the sheet; and

30            $\phi_2$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface for second side of the sheet.

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8. The method of claim 1, wherein determining at least one registration error comprises performing at least one geometrical transformation, including

$$L_{ME} = (L_{ME1} + L_{ME2}) / 2$$

where:

$L_{ME}$  is lateral magnification error of the sheet;

$L_{ME1}$  is lateral magnification error for first side of the sheet; and

$L_{ME2}$  is lateral magnification error for second side of the sheet.

9. The method of claim 1, wherein determining at least one registration error involves at least one geometrical transformation, including

$$P_{ME} = (P_{ME1} + P_{ME2}) / 2$$

where:

$P_{ME}$  is process magnification error;

$P_{ME1}$  is process magnification error for first side of the sheet; and

$P_{ME2}$  is process magnification error for second side of the sheet.

10. The method of claim 1, wherein determining at least one registration error involves at least one geometrical transformation, including

$$\alpha = \phi - \theta$$

where

$\alpha$  is target rotation;

$\phi$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface; and

$\theta$  is the amount of rotation of the sheet about the outboard registration edge of the sheet.

11. The method of claim 1, wherein determining at least one registration error involves at least one geometrical transformation, including

$$\Delta h_{\alpha} = h_2 * (1 - \cos(\theta))$$

where:

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$\theta$  is the amount of rotation of the sheet about the outboard registration edge of the sheet; and

$h_2$  is the distance from the trailing edge of second side of the sheet to the center of a trailing edge outboard crosshair located on the test pattern.

5        12.        The method of claim 1, wherein determining at least one registration error in image to sheet position in the lateral direction involves at least one geometrical transformation which determines the distance from the pivot point of the outboard shelf edge to a sheet leading edge target.

10        13.        The method of claim 1, wherein determining at least one registration error in image to sheet position in the process direction involves at least one geometrical transformation which determines the angular position of the LE target relative to the pivot point of the outboard edge of the sheet.

15        14.        The method of claim 1 wherein adjusting the at least one operational parameter comprises simultaneously adjusting a pixel clock frequency and/or a photoreceptor belt or drum speed, adjusting the first pixel delay after the start of scan location, varying sheet position or timing in the paper path, adjusting angular position of the ROS relative the photoreceptor belt.

20        15.        A control system usable to control a printing device, the printing device having a raster optical scanner, a photoreceptor belt or drum and a fuser, comprising:

an input device;

an input/output interface;

a controller;

at least one memory;

25        a setup circuit or routine that generates a test pattern, the test pattern being printed on a sheet of recording media, the setup circuit or routine using measured test pattern parameters obtained from the printed test pattern to determine registration errors in at least one of image squareness, image skew, sheet skew, process magnification, lateral magnification, image to sheet position in the lateral and  
30        process directions, and that uses the determined errors to simultaneously reduce at least two of the determined registration errors.

16.        The control system of claim 15, further including:

a system to print the test pattern on a first side of the image recording medium and on the second side of the image recording medium;

a system to measure test pattern parameters on the first side image and the second side image; and

a system to correct said errors by adjustment of at least one of a pixel clock frequency and a photoreceptor speed based on the determined errors.

17. The control system of claim 15, wherein the test pattern comprises a plurality of crosshair targets

18 The control system of claim 15, wherein a measured test pattern parameter is a sheet pivot point, a distance from a center of a leading edge crosshair located near the inboard leading edge of the sheet to a center of a trailing edge crosshair located near the outboard edge of the sheet, a distance from a center of a leading edge crosshair located near the outboard leading edge of the sheet to an outboard edge of the sheet, a distance between a center of a leading edge inboard crosshair to the center of a leading edge outboard crosshair, a distance between a center of a leading edge outboard crosshair to a center of a trailing edge outboard crosshair, a distance between a leading edge of the sheet to a center of a leading edge outboard crosshair, or a distance between a trailing edge of the sheet to the center of a trailing edge outboard crosshair.

19. The system of claim 15, wherein the setup circuit or routine to determine registration errors in paper skew comprises a circuit or routine to measure the test pattern parameters of  $d_1$ ,  $e_1$ ,  $f_1$ ,  $d_2$ ,  $e_2$  and  $f_2$  and to perform at least one geometrical transformation, including

$$\theta = (\tan^{-1}[(f_1 - e_1) / d_1] + \tan^{-1}[(f_2 - e_2) / d_2]) / 2$$

where  $\theta$  equals the amount of rotation of the sheet about the outboard registration edge of the sheet,  $d_1$  is the distance between the two leading edge (LE) crosshair centers on the first side of the sheet,  $e_1$  is the distance from the outboard (OB) edge of the sheet to the center of the leading edge (LE) outboard (OB) crosshair on the first side of the sheet,  $f_1$  is the distance from the outboard (OB) edge of the sheet to the center of the trailing edge (TE) outboard (OB) crosshair on the first side of the sheet,  $d_2$  is the distance between the two leading edge (LE) crosshair centers on the second side of the sheet,  $e_2$  is the distance from the outboard (OB) edge of the sheet to the

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center of the leading edge (LE) outboard (OB) crosshair on the second side of the sheet, and  $f_2$  is the distance from the outboard (OB) edge of the sheet to the center of the trailing edge (TE) outboard (OB) crosshair on the second side of the sheet.

20. The control system of claim 15, wherein determining at least one registration error in raster output scanner skew involves at least one geometrical transformation, including

$$\phi = (\phi_1 + \phi_2) / 2$$

where:

$\phi$  equals the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface;

$\phi_1$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface for first side of the sheet; and

$\phi_2$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface for second side of the sheet.

21. The control system of claim 15, wherein determining at least one registration error in image skew involves at least one geometrical transformation, including

$$L_{ME} = (L_{ME1} + L_{ME2}) / 2$$

where:

$L_{ME}$  is lateral magnification error of the sheet;

$L_{ME1}$  is lateral magnification error for first side of the sheet; and

$L_{ME2}$  is lateral magnification error for second side of the sheet.

22. The control system of claim 15, wherein determining at least one registration error involves at least one geometrical transformation, including:

$$P_{ME} = (P_{ME1} + P_{ME2}) / 2$$

where:

$P_{ME}$  is process magnification error;

$P_{ME1}$  is process magnification error for first side of the sheet; and

$P_{ME2}$  is process magnification error for second side of the sheet.

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23. The control system of claim 15, wherein determining at least one registration error involves at least one geometrical transformation, including:

$$\alpha = \phi - \theta$$

where:

$\alpha$  is target rotation;

$\phi$  is the amount of rotation of the raster output scanner about an axis perpendicular to the photoreceptor belt surface; and

$\theta$  is the amount of rotation of the sheet about the outboard registration edge of the sheet.

24. The control system of claim 20, wherein determining at least one registration error involves at least one geometrical transformation, including:

$$\Delta h_{\alpha} = h_2 * (1 - \cos(\theta)),$$

where:

$\theta$  is the amount of rotation of the sheet about the outboard registration edge of the sheet; and

$h_2$  is the distance from the trailing edge of second side of the sheet to the center of a trailing edge outboard crosshair located on the test pattern.

25. The control system of claim 15, wherein determining at least one registration error in image to sheet position in the lateral direction involves at least one geometrical transformation which determines the distance from the pivot point of the outboard shelf edge to a sheet leading edge target.

26. The control system of claim 15, wherein determining at least one registration error in image to sheet position in the process direction involves at least one geometrical transformation which determines the angular position of the LE target relative to the pivot point of the outboard edge of the sheet.

27. The control system of claim 15 wherein adjusting at least one operational parameter includes correcting a pixel clock frequency and/or a photoreceptor belt or drum speed, adjusting the first pixel delay after the start of scan location, adjusting sheet position or timing in the paper path, and adjusting angular position of the raster output scanner relative to the photoreceptor belt.

28. A method of determining and reducing image on sheet registration errors of a printing machine comprising:

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providing a test pattern on a sheet;  
making measurements of a plurality of registration errors based on the  
test pattern;  
determining error corrections for the plurality of registration errors  
5 using an algorithm; and  
providing the error corrections to at least one of a printing machine or  
printing machine operator to correct the plurality of registration errors.

28. The method of claim 27, wherein the plurality of registration errors  
include two or more of image squareness, image skew, sheet skew, process  
10 magnification, lateral magnification, image to sheet position in the lateral direction  
and image to sheet position in the process direction.

29. A system of determining and reducing image on sheet registration  
errors of a printing machine comprising:  
a test pattern provider to provide a test pattern on a sheet;  
15 a measurer to making measurements of a plurality of registration errors  
based on the test pattern;  
an error corrector to determine error corrections for the plurality of  
registration errors using an algorithm; and  
an error correction provider to provide error corrections to at least one  
20 of a printing machine or printing machine operator to correct the plurality of  
registration errors.

30. The system of claim 27, wherein the plurality of registration errors  
include two or more of image squareness, image skew, sheet skew, process  
magnification, lateral magnification, image to sheet position in the lateral direction  
25 and image to sheet position in the process direction.

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